

B263

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

**(19) World Intellectual Property Organization
International Bureau**



**(43) International Publication Date
25 October 2001 (25.10.2001)**

PCT

(10) International Publication Number
WO 01/79589 A1

(51) International Patent Classification⁷: C23F 1/08, C23
3/00, 5/00, C25D 21/08, C25F 7/00 // C25D 1/10

(21) International Application Number: PCT/SE01/00823

(22) International Filing Date: 12 April 2001 (12.04.2001)

(25) Filing Language: Swedish

(26) Publication Language: English

(30) Priority Date:
0001369-8 13 April 2000 (13.04.2000) SE

(71) Applicant (for all designated States except US): OBDU-CAT AKTIEBOLAG [SE/SE]; Box 580, S-201 25 Malmö (SE).

(72) Inventor; and

(75) Inventor/Applicant (for US only): HÄLLBERG, Mats [SE/SE]; Merkuriusvägen 25, S-181 63 Lidingö (SE).

(74) Agent: AWAPATENT AB; Box 5117, S-200 71 Malmö (SE).

(81) **Designated States (national):** AE, AG, AL, AM, AT, AT
(utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA,
CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE
(utility model), DK, DK (utility model), DM, DZ, EE, EE
(utility model), ES, FI, FI (utility model), GB, GD, GE, GH,
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SL, SK,
SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US,
UZ, VN, YU, ZA, ZW.

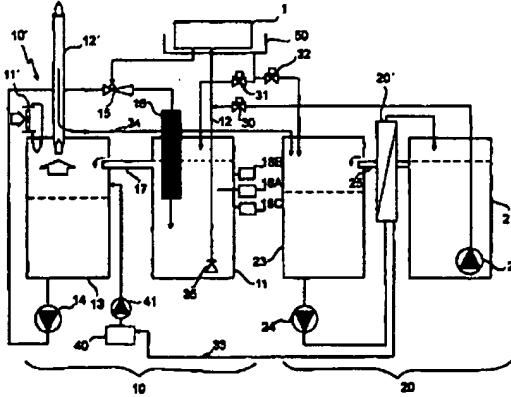
(84) Designated States (*regional*): ARIPo patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD IN AND APPARATUS FOR ETCHING OR PLATING OF SUBSTRATES



(57) Abstract: In a method for processing a substrate (S), for instance by etching or plating, use is made of an apparatus comprising a chamber (1) for receiving the substrate (S), a unit (10) for feeding a processing fluid to the chamber (1) before and/or during processing, and a flushing unit (20) for cleaning the substrate (S) by means of a flushing fluid after completed processing. The flushing unit (20) comprises a flushing fluid tank (21), a cleaning device (20') and a fluid feeding means (22, 24), the fluid feeding means (22, 24) being arranged to feed from the flushing fluid tank (21) the flushing fluid through the chamber (1) for cleaning the substrate (S) received therein, through the cleaning device (20') for cleaning the flushing fluid and back to the flushing fluid tank (21). Thus, the working operations for cleaning the processed substrate (S) are significantly simplified. The cleaning can easily be automated without necessitating expensive auxiliary equipment. Moreover cleaning takes place in an essentially closed environment inside the chamber (1), thereby minimising the environment's exposure to substances which are dangerous to health. Moreover, an essentially closed process with a minimum of emissions of environmentally dangerous residual products, such as metal ions, is made possible.

WO 01/79589 A1

BEST AVAILABLE COPY

Method in and apparatus for etching or plating of substrates.

METHOD IN AND APPARATUS FOR ETCHING OR PLATING OF SUBSTRATES.

Field of the Invention

The present invention relates generally to processing of substrates, e.g. by plating or etching.

The invention relates specifically to cleaning of a substrate after completed processing.

The present invention is especially usable in electrochemical plating and etching. Therefore the description of background art, as well as objects of the invention and embodiments thereof, will be given 10 with reference to such electrochemical processing, in particular plating. However, the invention is also applicable to other processing of a surface of a substrate, for instance in chemical etching or in dissolving of surface layers, such as resist layers after exposure, by means of a solvent or the like.

Background Art

It is many cases desirable to produce small structures in a material surface of a substrate. This can be achieved by electrochemical plating of the substrate.

20 Alternatively, the substrate can be subjected to electrochemical etching. In both cases, such electrochemical processing takes place in a cell or container, which defines a chamber containing at least one electrode and an opposite substrate holder. The electrode and the substrate holder are connected to a voltage source, which during the electrochemical processing establishes an electrical field between the electrode and a substrate carried by the substrate holder. An electrolyte is received between the electrode and the substrate. In a 30 plating process, ions pass from the electrolyte and are deposited on the surface of the substrate. In an etching process, parts of the surface of the substrate are dissolved and pass to the electrolyte in the form of ions.

In one type of plating process, the surface of the substrate can be provided with the desired structure, so that an inverted copy is transferred to the metal layer which is deposited on the substrate acting as a cathode.

- 5 The thus structured metal layer can then be released from the substrate and used as a stamper (matrix), for instance in injection moulding of various products, such as CD, CD ROM, DVD etc. and also vinyl records, holograms etc., or in so-called nanoimprint lithography for manufacturing structures in semiconductor materials etc.
- 10 Alternatively, the structured metal layer can be used as a so-called father by a new metal layer being deposited thereon for making an inverted copy which is used either as a stamper as above or as a so-called mother on which
- 15 a metal layer is deposited in order to form sons which in turn are used as stampers. This type of plating is disclosed in e.g. US-A-5,843,296 and US-A-5,427,674. In an alternative plating process, an unstructured substrate is arranged as a cathode in the chamber. By suitable
- 20 masking of the substrate, a desired structure can be formed on the same during plating. According to one more alternative plating process, an even metal layer is deposited on an unstructured substrate. This plating process thus results in an unstructured raw matrix of high sur-
- 25 face smoothness which in a separate subsequent step is structured by a suitable method, such as etching. This type of method is disclosed in WO99/63535.

- 30 In an etching process, the substrate, which is arranged as an anode in the chamber, can be structured by suitable masking thereof. Alternatively, an electrode surface can be caused to move in a given pattern over the substrate. Different types of electrochemical etching are known from e.g. EP-A-392 738, WO98/10121 and EP-A-563 744. Like in plating, the structured substrate can be used directly as a stamper, for instance in injection moulding or in nanoimprint lithography, or be used for making a mother etc.
- 35

In a conventional plating chamber, such as described in e.g. US-A-5,427,674, the anode is formed as a basket of titanium, which carries balls or rods of the metal to be deposited on the substrate. At the same rate as metal ions are deposited on the substrate from the electrolyte, new metal ions are released from the balls or rods to the electrolyte so that its metal ion content is essentially constant. In an alternative embodiment, which is also mentioned in the above US-A-5,427,674, a dimensional stable, plate-shaped anode (DSA) of e.g. platinum-coated titanium is used instead. The plating chamber is provided with a compensating device which is adapted to supply in a dosed manner to the electrolyte a metal hydroxide so as to compensate for the metal ions which are removed from the electrolyte and deposited on the substrate. In this embodiment, a smaller distance between anode and cathode is allowed, which in turn allows higher current density between anode and cathode and also lower power consumption.

When the plating process in the chamber is completed, the substrate and the metal deposited thereon are cleaned from electrolyte by means of a flushing fluid, usually clean ion-free water. This cleaning takes place by the chamber being opened and the substrate transferred to a separate flushing unit. During cleaning, the flushing fluid will be mixed with electrolyte, and the resulting waste fluid mixed with metal ions will be a residual product that must be taken care of. In many cases, the transfer of the substrate to the flushing unit occurs manually, which means that the operator is exposed to substances in the electrolyte which are injurious to health, such as nickel. In manual handling, there is also a certain risk of contamination of the electrolyte that is present in the plating chamber. An automated cleaning of the plated substrate requires expensive equipment, such as a computer-controlled robot unit, for transfer-

ring the substrate from the plating chamber to the flush-ing unit.

The above problems are also to be found in prior-art apparatus for chemical or electrochemical etching, and
5 dissolution of a surface layer, for instance an exposed resist layer, on a substrate.

Object of the Invention

It is an object of the present invention to wholly or at least partly overcome the above problems according
10 to prior-art technique, and in particular to provide a method in processing a substrate as well as a processing apparatus which minimises the emission of environmentally dangerous residual products.

It is also an object to reduce the operator's expo-
15 sure to substances which are injurious to health during cleaning of the processed substrate.

One more object is to minimise the risk of contami-nation of the processing fluid, i.e. the electrolyte, the etchant or the solvent, during cleaning of a substrate
20 processed with this processing fluid.

Summary of the Invention

These and other objects that will be evident from the following description are now achieved by a method and an apparatus according to the independent claims.
25 Preferred embodiments are defined in the dependent claims.

An advantage of the inventive method is that the substrate is flushed with a flushing fluid in situ in the processing chamber. Thus, the working operations
30 for cleaning the processed substrate are significantly simplified. The cleaning can easily be automated without necessitating expensive auxiliary equipment. Moreover, the cleaning takes place in an essentially closed envi-ronment inside the chamber, which means that the envi-
35 ronment's exposure to substances dangerous to health is minimised. Thanks to the fact that the flushing fluid after passing the chamber is cleaned by means of a clean-

ing device and recirculated to the flushing fluid tank, an essentially closed process with a minimum of emissions of environmentally dangerous residual products, such as metal ions, is made possible.

5 According to a preferred embodiment, any flushing fluid admixed to the processing fluid is separated from the processing fluid, after which the thus separated flushing fluid via the cleaning device is recirculated to the flushing fluid tank. This measure makes it possible to continuously maintain a given quality of the processing fluid.

10 According to another preferred embodiment, the processing fluid is fed through the chamber during processing, preferably by processing fluid during processing being circulated between a first processing fluid tank and the chamber, while at the same time processing fluid is circulated between the first processing fluid tank and a second processing fluid tank. Thus, processing fluid of a desirable quality can always be supplied to the chamber 15 from the first tank. For instance, in electrochemical processing, the ion concentration of the processing fluid can be adjusted in the second tank, from which the processing fluid can be supplied via a filter to the first tank, so that a clean processing fluid of optimal concentration is available therein. Moreover the processing 20 fluid can be kept at a given level in the first tank, for instance by means of an overflow connected to the second tank, in order to eliminate the arising of variations in the flow of processing fluid through the chamber. Moreover, flushing fluid admixed to the processing fluid can 25 be separated from the processing fluid in the second tank. This can easily be carried out by a gas flow being supplied above the processing fluid in the second tank and by this gas flow being received and cooled in a condenser to form a condensate containing the admixed flushing 30 fluid.

35

According to another preferred embodiment, especially intended for electrochemical plating, the ion concentration of the processing fluid, i.e. the electrolyte, in the second tank is adjusted by a dosed supply of alkaline 5 anions and metal ions which are identical with metal ions present in the electrolyte. This embodiment is particularly preferred when using a dimensionally stable anode in the chamber. Thus, a constant metal ion content can easily be maintained in the electrolyte. Preferably, a 10 filter is arranged between the second tank and the first tank, so that undissolved residues of the added ions can be prevented from reaching the first tank and from this the chamber. Preferably, the anions and metal ions can be supplied as a slurry of an alkaline metallic salt. The 15 supply of the alkaline metallic salt is controlled preferably based on the pH of the electrolyte received in the first or second tank. Consequently, simple and accurate control is allowed. During the plating process, hydrogen ions in fact form at the anode in proportion 20 to the amount of deposited metal ions on the substrate, which means that the pH also indicates the metal ion content of the electrolyte. It is preferred for the alkaline metallic salt to contain anions in the form 25 of carbonate ions, hydroxide ions, oxide ions or oxide hydroxide ions since these are capable of neutralising the formed hydrogen ions without giving rise to undesired residual products in the electrolyte.

According to another preferred embodiment, the flushing fluid is cleaned after passing the chamber in 30 the cleaning device by separating ions dissolved in the flushing fluid, and said ions are recirculated to the processing fluid, preferably to the second tank. This permits an essentially fully closed process with minimum amounts of residual products. The recirculation of the 35 ions can take place manually or automatically.

According to another preferred embodiment, the flushing fluid fed through the chamber is directed during

a first period of time to the first or the second tank and during a subsequent second period of time via the cleaning device to the flushing fluid tank. Thus, the amount of processing fluid that is admixed to the flushing fluid can be minimised. This is advantageous since as a rule it is easier to remove flushing liquid, typically water, from the processing fluid than processing fluid from the flushing fluid.

According to a preferred embodiment, the flushing fluid fed through the chamber is transferred to a secondary tank, and the flushing fluid is supplied from the secondary tank to the flushing fluid tank via the cleaning device, which collects the ions dissolved in the flushing fluid. By contaminated flushing fluid being supplied to the secondary tank, flushing fluid of a desirable quality is always available in the flushing fluid tank. Moreover the flushing fluid can be kept at a given level in the flushing fluid tank, for instance by means of an overflow connected to the secondary tank, in order to minimise the risk of production troubles during the flushing of the substrate.

It is also preferred for a subatmospheric pressure to be generated in the chamber during processing. The risk of processing fluid leaking from the chamber is thus easily eliminated. Furthermore the sealing of the chamber can be simplified since the subatmospheric pressure automatically strives to keep the parts of the chamber together.

According to a preferred embodiment, the processing fluid circulating between the first and second tanks passes through an ejector, which during generation of a subatmospheric pressure in the chamber draws electrolytes from this and thus causes the processing fluid to circulate between the first tank and the chamber. Consequently the number of pumps or the like can be minimised since one pump can perform the circulation of processing fluid both between the first and second tanks and between the

first tank and the chamber. Furthermore a subatmospheric pressure in the chamber can easily be achieved, for instance by suitable adaption of the suction effect of the ejector to the dimension of the processing fluid

5 inlet of the chamber.

According to one more preferred embodiment, the circulation of processing fluid between the first and second tanks is interrupted after completed processing, whereby also the circulation of processing fluid between the
10 first tank and the chamber is interrupted, after which flushing fluid is supplied from the flushing fluid tank to the chamber so as to generate a pressure above atmospheric in the chamber, which is thus opened and allows the flushing fluid to flow down into a collecting vessel.
15 This method is simple and robust since the chamber is automatically opened when being filled with flushing fluid. Conveniently the chamber is opened only to such an extent that the flushing fluid can flow out, in order to minimise the environment's exposure to substances
20 injurious to health.

The above discussion of preferred embodiments of the inventive method is correspondingly applicable also to the apparatus according to the invention.

Brief Description of the Drawings

25 The drawings will now be described in more detail with reference to the accompanying drawings which by way of example illustrate a currently preferred embodiment relating to plating.

Fig. 1 is a schematic view of an embodiment of a
30 plating apparatus according to the invention.

Fig. 2 shows in more detail a plating apparatus corresponding to the embodiment in Fig. 1.

Description of a Preferred Embodiment

35 The preferred embodiment of an inventive plating apparatus will in the following first be described generally with reference to Fig. 1. The plating apparatus comprises a plating chamber 1 with an anode 2 and an

opposite cathode holder (not shown), which carries the substrate S which is to be plated. A voltage source (not shown) is connected to the anode 2 and the cathode holder in order to establish during the plating process an electrical field between the anode 2 and the substrate S, which acts as a cathode. An electrolyte feeding system 10 communicates with the chamber 1 to feed an electrolyte through the chamber 1 during plating. A flushing water system 20 also communicates with the chamber 1 in order 5 to feed flushing water through the chamber 1 after completed plating, for washing of the plated substrate S. Valves 30, 31, 32 are arranged to selectively control the feeding of electrolyte and flushing water to and from the chamber 1. The flushing water system 20 comprises a 10 cleaning device 20' which is designed to separate ions from incoming flushing water. A conduit 33 extends from the cleaning device 20' to the electrolyte feeding system 10 for transferring separated ions to the same. The electrolyte feeding system 10 contains a concentrating device 15 10' which is designed to separate water from the electrolyte. A conduit 34 extends from the concentrating device 10' to the flushing water system 20 for transferring separated fluid to the same.

The apparatus shown in Fig. 1 generally operates in 20 the following fashion. During plating, the valves 30, 32 are closed and the valve 31 open, and electrolyte is circulated continuously between the electrolyte feeding system 10 and the chamber 1. The system continuously conditions the electrolyte, inter alia with regard to its 25 metal ion content, pH and temperature. After completed plating, the plated substrate S is flushed in situ in the chamber 1 by the valve 30 being opened and flushing water being pumped into the chamber 1. A non-return valve 35 prevents flushing water from flowing into the electrolyte 30 feeding system 10. During a first period of time, the flushing water is allowed to press electrolyte out of the chamber 1 and into the system 10. When almost all

the electrolyte has been pressed out, the valve 31 is closed and the valve 32 is opened, so that flushing water and the remaining electrolyte are allowed to circulate between the flushing water system 20 and the chamber 1.

- 5 The plated substrate S is flushed clean from electrolyte. The cleaning device 20' of the system continuously cleans the flushing water received from the chamber 1. In the meantime the concentrating device 10' operates to separate any flushing water admixed to the electrolyte and
- 10 transfer this to the cleaning device 20' of the system 20. Subsequently the apparatus is ready to perform a new plating process. The plating apparatus is suitably controlled by a main control unit (not shown).

The construction and function of the apparatus in
15 Fig. 1 will now be described in more detail with reference to Fig. 2.

The electrolyte feeding system 10 comprises a first tank 11, which via a feeding duct 12 communicates with the chamber 1, and a second tank 13, which via a pump 14,
20 an ejector 15 and a particle filter 16 communicates with the first tank 11. The suction side of the ejector 15 communicates with an electrolyte outlet of the chamber 1. The first tank 11 has an overflow 17 which communicates with the second tank 13. The concentrating device 10' of
25 the system 10 comprises an air fan 11' which communicates with the upper part of the second tank 13, and a cooling tower 12' extending from the upper part of the tank 13. The first tank 11 is provided with a heater 18A for heating the electrolyte, a temperature sensor 18B and a pH
30 meter 18C.

In the preferred embodiment, the anode 2 (Fig. 1) in the chamber 1 is a dimensionally stable anode which is essentially inert relative to the electrolyte. The metal ions in the electrolyte which are consumed during plating
35 are replaced in this case by means of a compensating device 40 which prepares a water-based slurry containing

corresponding metal ions. A pump 41 is designed for dosed supply of the slurry to the second tank 13.

The choice of electrolyte is of course controlled by which metal is to be deposited on the substrate S (Fig. 1). In nickel plating, the electrolyte can be based on e.g. nickel sulphamate and water. In this case hydrogen ions are formed at the anode 2 during plating while at the same time nickel ions are precipitated on the substrate S. These hydrogen ions are neutralised by supplying an alkaline substance. This takes place by means of the compensating device 40, which prepares the slurry of an alkaline metallic salt, in this case nickel carbonate, nickel hydroxide, nickel oxide or nickel oxide hydroxide. The anions of the salt react with the hydrogen ions and form, depending on the salt chosen, water or carbon dioxide. Owing to the metal ions and the alkaline substance being supplied in the form of a salt, metal ions can be supplied in a controlled fashion to the electrolyte based on the pH of the electrolyte measured by the meter 18C.

The flushing water system 20 comprises a clean water tank 21, which via a feeding pump 22 and the valve 30 communicates with the feeding duct 12 and the chamber 1, and a secondary tank 23, which via a pump 24 and the cleaning device 20' communicates with the clean water tank 21. The cleaning device 20' is an ion filter, for instance a filter for reverse osmosis. The cleaning device 20' is designed to separate ions from the flushing water and has an ion outlet which via the duct 33 is connected to the compensating device 40 for transferring ion concentrate to this. The cleaning water tank 21 has an overflow 25 which communicates with the secondary tank 23. The secondary tank 23 communicates with the cooling tower 12' via the duct 34 for receiving condensed water from the same.

The plating chamber 1 has a pressure-controlled outlet (not shown) which is closed at subatmospheric

pressure in the chamber 1 and is open at pressure above atmospheric in the same. For instance, the plating chamber 1 may consist of two parts which are held together at internal subatmospheric pressure and which automatically 5 are separated at internal pressure above atmospheric. A collecting vessel 50 is arranged under the plating chamber 1 for receiving electrolyte and flushing water from the pressure-controlled outlet, as will be described in more detail below. The collecting vessel 50 communicates 10 via the respective valves 31, 32 with the first tank 11 and the secondary tank 23.

The plating apparatus shown in Fig. 2 operates as follows. During plating, the valves 30, 31, 32 are closed. The pump 14 feeds electrolyte from the second tank 15 13 through the ejector 15 to the first tank 11. The ejector 15 draws electrolyte from the chamber 1 into the first tank 11, and the suction effect of the ejector 15 causes electrolyte to circulate in a loop between the first tank 11 and the chamber 1. This loop is designed in 20 such manner that a subatmospheric pressure is established in the chamber 1. The filter 16 separates any particles in the electrolyte. Via the overflow 17, a stable electrolyte level is established in the first tank 11. The compensating device 40 feeds the slurry to the second tank 13 based on the output signal of the pH meter 18C. The concentrating device 10' separates continuously or 25 intermittently water from the electrolyte in the second tank 13 and transfers this water to the secondary tank 23.

30 After the plating has been completed, the plated substrate S is flushed in situ in the chamber 1 by the pump 14 being stopped, the valve 30 being opened and the feeding pump 22 being started to pump flushing water into the chamber 1. The non-return valve 35 prevents the 35 flushing water from flowing into the first tank 11. The water flowing into the chamber 1 increases the pressure in the chamber 1 so that its pressure-controlled outlet

(not shown) is automatically opened and the electrolyte is pressed out into the collecting vessel 50. At the same time the valve 31 is caused to open so that the electrolyte is allowed to flow down into the first tank 11. When 5 almost all the electrolyte has been pressed out of the chamber 1, the valve 31 is closed and the valve 32 is opened, so that flushing water and the remaining electrolyte are allowed to flow down into the secondary tank 23. The chamber 1 is now passed by flushing water, and elec- 10 trolyte is flushed away from the plated substrate S. In the meantime the pump 24 is started, and contaminated flushing water is fed from the secondary tank 23 through the filter 20' to the clean water tank 21. A stable water level is maintained in the clean water tank 21 by means 15 of the overflow 25. During the flushing process, the fan 11' is activated to feed a flow of air above the electrolyte in the second tank 13. This flow of air entrains water vapour from the electrolyte and flows up in the cooling tower 12', in which the water vapour is made to 20 condense. The formed condensate is transferred to the secondary tank 23, from which it is pumped via the filter 20' to the clean water tank 21 which always contains essentially ion-free flushing water.

Thus, according to the invention a method and an 25 apparatus are provided which in a cost-efficient and simple manner minimise the emission of residual products which are harmful to the environment. Moreover, the operator's exposure to substances dangerous to health when cleaning the plated substrate is reduced. Also the risk 30 of contamination of the electrolyte when cleaning a plated substrate is minimised.

It should be noted that the invention is not restricted to the above detailed description of the currently preferred embodiment, and can be modified 35 within the scope of the appended claims. The apparatus described above can to a large extent also be used for electrochemical etching of a substrate. The basic prin-

ciples of the invention can also be applied to chemical etching of a substrate, and to dissolving a surface layer on a substrate, for instance after exposing a resist layer, for masking the substrate before a subsequent 5 etching or plating step.

It may also be noted that in some applications there may be reason to operate with a pressure above atmospheric in the processing chamber.

In some applications, the chamber need not be continuously passed by a processing fluid during processing. 10 For example, it may in some kind of electrochemical etching be sufficient to supply processing fluid to the chamber before the actual processing starts.

CLAIMS

1. A method in processing a substrate (S) in a chamber (1), comprising the steps of, before and/or during processing, supplying a processing fluid, such as an electrolyte, an etchant or a solvent, to the chamber (1) and, after completed processing, flushing the substrate (S) with a flushing fluid, characterised in that the substrate (S) is flushed in situ in the chamber (1) by feeding the flushing fluid through the chamber (1) from a flushing fluid tank (21), and cleaning the flushing fluid, after passing the chamber (1), by means of a cleaning device (20') and recirculating the flushing fluid to the flushing fluid tank (21).

2. A method as claimed in claim 1, comprising the steps of separating from the processing fluid any flushing fluid admixed thereto, and via the cleaning device (20') recirculating the thus separated flushing fluid to the flushing fluid tank (21).

3. A method as claimed in claim 1 or 2, comprising the steps of circulating, during processing, processing fluid between a first processing fluid tank (11) and the chamber (1) and simultaneously circulating processing fluid between the first processing fluid tank (11) and a second processing fluid tank (13).

4. A method as claimed in claim 3, comprising the step of separating in the second tank (13) from the processing fluid any flushing fluid admixed thereto and, via the cleaning device (20'), recirculating the thus-separated flushing fluid to the flushing fluid tank (21).

5. A method as claimed in claim 4, wherein the step of separating any flushing fluid admixed to the processing fluid comprises supplying a gas flow above the processing fluid in the second tank (13), and in a condenser (12') receiving and cooling the gas flow to form a condensate containing the admixed flushing fluid.

6. A method as claimed in any one of claims 3-5, comprising the step of adding in a dosed manner to the flushing fluid in the second tank (13) alkaline ions and metal ions which are identical with metal ions present in
5 the processing fluid, preferably as a slurry of an alkaline metal salt.

7. A method as claimed in claim 6, wherein the addition of the alkaline to the salt is controlled based on the pH of the processing fluid contained in the first or
10 the second tank (11, 13).

8. A method as claimed in any one of claims 3-7, comprising the step of keeping the processing fluid at a given level in the first tank (11).

9. A method as claimed in any one of claims 3-8,
15 wherein the flushing fluid, after passing the chamber (1), is cleaned by means of the cleaning device (20') by separating ions dissolved in the flushing fluid, and wherein said ions are recirculated to the processing fluid, preferably to the second tank (13).

20 10. A method as claimed in any one of claims 3-9, comprising the steps of directing, during a first period of time, the flushing fluid fed through the chamber (1) to the first or the second tank (11, 13), and directing, during a subsequent second period of time, the flushing
25 fluid fed through the chamber (1) via the cleaning device (20') to the flushing fluid tank (21).

11. A method as claimed in any one of claims 1-10, comprising the steps of transferring the flushing fluid fed through the chamber (1) to a secondary tank (23), and
30 supplying the flushing fluid from the secondary tank (23) to the flushing fluid tank (21) via the cleaning device (20') which collects ions dissolved in the flushing fluid.

12. A method as claimed in claim 11 in combination
35 with claim 4 or 5, comprising the step of transferring the flushing fluid separated from the processing fluid to the secondary tank (23).

13. A method as claimed in claim 11 or 12, comprising the step of keeping the flushing fluid at a given level in the flushing fluid tank (21) by recirculating flushing fluid to the secondary tank (23).

5 14. A method as claimed in any one of claims 1-13, comprising the step of generating a subatmospheric pressure in the chamber (1) during processing.

10 15. A method as claimed in claim 3, wherein the processing fluid circulating between the first and second tanks (11, 13) passes through an ejector (15), which during generation of a subatmospheric pressure in the chamber (1) draws processing fluid therefrom and thus causes processing fluid to circulate between the first tank (11) and the chamber (1).

15 16. A method as claimed in claim 15, comprising the steps of interrupting, after completed processing, the circulation of processing fluid between the first and second tanks (11, 13), and thus also interrupting the circulation of processing fluid between the first tank 20 (11) and the chamber (1), supplying flushing fluid from the flushing fluid tank (21) to the chamber (1) so that a pressure above atmospheric is generated in the chamber (1), which is consequently opened and allows the flushing fluid to flow down into a collecting vessel (50), directing during a first period of time the flushing fluid from the collecting vessel (50) to the first or the second tank (11, 13), and during a subsequent second period 25 of time directing the flushing fluid from the collecting vessel (50) via a cleaning device (20') to the flushing 30 fluid tank (21).

17. An apparatus for processing a substrate, comprising a chamber (1) for receiving the substrate (S), a unit (10) for supplying a processing fluid, such as an electrolyte, an etchant or a solvent, to the chamber (1) before and/or during processing, and a flushing unit (20) 35 for cleaning the substrate (S) by means of a flushing fluid after completed processing, characteris -

ed in that the flushing unit (20) comprises a flushing fluid tank (21), a cleaning device (20') and a fluid feeding means (22, 24), the fluid feeding means (22, 24) being adapted to feed from the flushing fluid tank (21) 5 the flushing fluid through the chamber (1) for cleaning the substrate (S) contained therein, through the cleaning device (20') for cleaning the flushing fluid and back to the flushing fluid tank (21).

18. An apparatus as claimed in claim 17, wherein the 10 feeding unit (10) for processing fluid comprises a fluid separating means (10') which is designed to separate from the processing fluid any flushing fluid admixed thereto, the fluid separating means (10') being in fluid communication with the flushing fluid tank (21) via the cleaning 15 device (20') for recirculating thus separated flushing fluid.

19. An apparatus as claimed in claim 17 or 18, wherein the feeding unit (10) for processing fluid comprises a first processing fluid tank (11), a second processing fluid tank (13) and a feeding means (14, 15) for processing fluid, which is designed to circulate processing fluid between the first tank (11) and the chamber (1) and simultaneously circulate processing fluid between the first and second tanks (11, 13).

20. An apparatus as claimed in claim 19, wherein the first processing fluid tank (11) comprises a level control means (17), preferably an overflow which is connected to the second tank (11) and which is adapted to maintain a given level of the processing fluid in the first 30 tank (11).

21. An apparatus as claimed in claim 19 or 20, wherein a fluid separating means (10') is allocated to the second tank (13) and designed to separate from the processing fluid any flushing fluid admixed thereto, the 35 fluid separating means (10') being in fluid communication with the flushing fluid tank (21) via the cleaning device (20') for recirculating thus separated flushing fluid.

22. An apparatus as claimed in claim 21, wherein the fluid separating means (10') comprises a pump means (11') which is adapted to supply a gas flow above the processing fluid in the second tank (13) and a condenser (12') which is adapted to receive from the second tank (13) the gas flow and cool the same to form a condensate containing the admixed flushing fluid.

5 23. An apparatus as claimed in any one of claims
19-22, comprising a conditioning means (40, 41) which is
10 designed to add in a dosed manner to the processing fluid
in the second tank (13) alkaline anions and metal ions
which are identical with metal ions present in the pro-
cessing fluid, preferably as a slurry of an alkaline
metallic salt.

15 24. An apparatus as claimed in claim 23, comprising
a pH meter (18C) which in the first or second tank (11,
13) is adapted to measure the pH of the processing fluid,
the conditioning means (40, 41) being designed to con-
trol, based on said pH, the supply of the alkaline metal-
20 lic salt.

19-24, 25. An apparatus as claimed in any one of claims
wherein the cleaning device (20') is designed to
separate ions dissolved in the flushing fluid, and where-
in the feeding unit (10) for processing fluid comprises a
25 means (40) for recirculating said ions to the processing
fluid, preferably in the second tank (13).

19-25, 26. An apparatus as claimed in any one of claims
wherein the flushing unit (20) further comprises
a secondary tank (23), and wherein the fluid feeding
30 means (22, 24) is designed to transfer the flushing fluid
fed through the chamber (1) to the secondary tank (23),
and feeding the flushing fluid from the secondary tank
(23) to the flushing fluid tank (21) via the cleaning
device (20') which is designed to collect ions dissolved
35 in the flushing fluid.

27. An apparatus as claimed in claim 26 in combina-
tion with claim 21 or 22, wherein the fluid separating

means (10') is in fluid communication with the secondary tank (23) for recirculating the separated flushing fluid.

28. An apparatus as claimed in claim 26 or 27,
wherein the flushing fluid tank (21) comprises a level
5 control means (25), preferably an overflow connected to
the secondary tank (23) and adapted to maintain a given
level of the flushing fluid in the flushing fluid tank
(21).

29. An apparatus as claimed in any one of claims
10 19-28, wherein a valve means (31, 32) is controllable to
direct, during a first period of time, the flushing fluid
fed through the chamber (1) to the first or the second
tank (11, 13), and to direct, during a subsequent second
period of time, the flushing fluid fed through the cham-
15 ber (1) via the cleaning device (20') to the flushing
fluid tank (21).

30. An apparatus as claimed in any one of claims
17-29, wherein the feeding means (14, 15) for processing
fluid is adapted to generate a subatmospheric pressure
20 in the chamber (1) during processing.

31. An apparatus as claimed in claim 19, wherein the
feeding unit (10) for processing fluid comprises a pump
means (14) and an ejector (15), the pump means (14) being
adapted to circulate processing fluid between the first
25 and second tanks (11, 13), the ejector (15) being arrang-
ed between the first and second tanks (11, 13) and having
a suction side which is in fluid communication with the
chamber (1) so that, when the pump means (14) is activat-
ed to circulate via the ejector (15) processing fluid
30 between the first and second tanks (11, 13), the ejector
(15) during generation of a subatmospheric pressure in
the chamber (1) draws processing fluid from the same and
thus causes processing fluid to circulate between the
first tank (11) and the chamber (1).

35 32. An apparatus as claimed in claim 31, wherein the
pump means (14), when processing is completed, is dis-
activatable to interrupt the circulation of processing

fluid between the first and second tanks (11, 13) and thus also interrupt the circulation of processing fluid between the first tank (11) and the chamber (1), after which the fluid feeding means (22, 24) is activatable to
5 feed flushing fluid from the flushing fluid tank (21) to the chamber (1) for generating a pressure above atmospheric in the same and opening a fluid outlet of the same, a collecting vessel (50) being adapted to receive flushing fluid flowing out of the fluid outlet of the chamber (1),
10 and a valve means (31, 32) being controllable to direct, during a first period of time, the flushing fluid from the collecting vessel (50) to the first or the second tank (11, 13) and to direct, during a subsequent second period of time, the flushing fluid from the collecting
15 vessel (50) via the cleaning device (20') to the flushing fluid tank (21).

33. A method in processing a substrate (S) in a chamber (1), comprising the steps of supplying, before and/or during processing, a processing fluid, such as an
20 electrolyte, an etchant or a solvent, to the chamber (1) and, after completed processing, flushing the substrate (S) with a flushing fluid, characterised in that the substrate (S) is flushed in situ in the chamber (1) by flushing fluid being fed through the chamber (1)
25 from a flushing fluid tank (21), and that the flushing fluid after passing the chamber (1) is cleaned by means of a cleaning device (20') and recirculated to the flushing fluid tank (21), which also comprises the steps of circulating, during processing, processing fluid between
30 a first processing fluid tank (11) and the chamber (1) and simultaneously circulating processing fluid between the first processing fluid tank (11) and a second processing fluid tank (13).

34. An apparatus for processing a substrate, comprising a chamber (1) for receiving the substrate (S),
35 a unit (10) for supplying a processing fluid, such as an electrolyte, an etchant or a solvent, to the chamber (1)

before and/or during processing, and a flushing unit (20) for cleaning the substrate (S) by means of a flushing fluid after completed processing, characterized in that the flushing unit (20) comprises a flushing fluid tank (21), a cleaning device (20') and a fluid feeding means (22, 24), the fluid feeding means (22, 24) being adapted to feed from the flushing fluid tank (21) the flushing fluid through the chamber (1) for cleaning the substrate (S) contained therein, through the cleaning device (20') for cleaning the flushing fluid and back to the flushing fluid tank (21), and the feeding unit (10) for processing fluid comprising a first processing fluid tank (11), a second processing fluid tank (13) and a feeding means (14, 15) for processing fluid, which is designed to circulate processing fluid between the first tank (11) and the chamber (1) and simultaneously circulating processing fluid between the first and second tanks (11, 13).

1/2

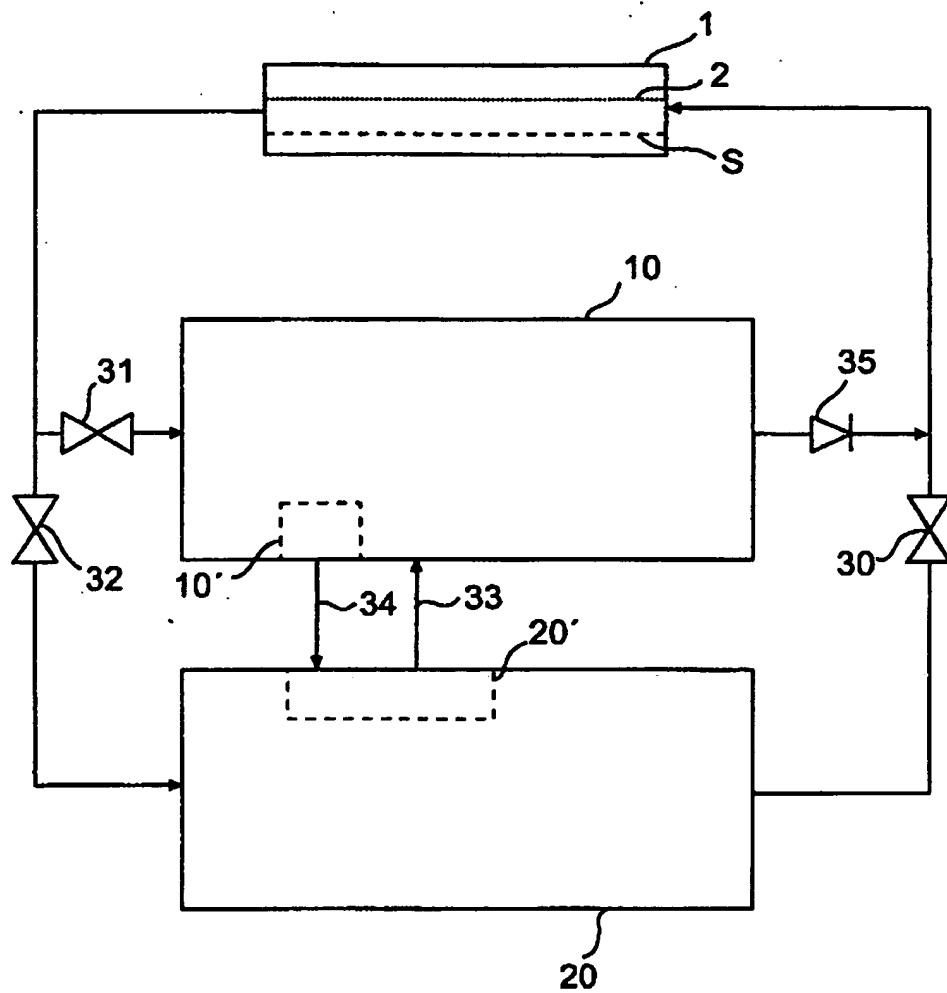


Fig. 1

2/2

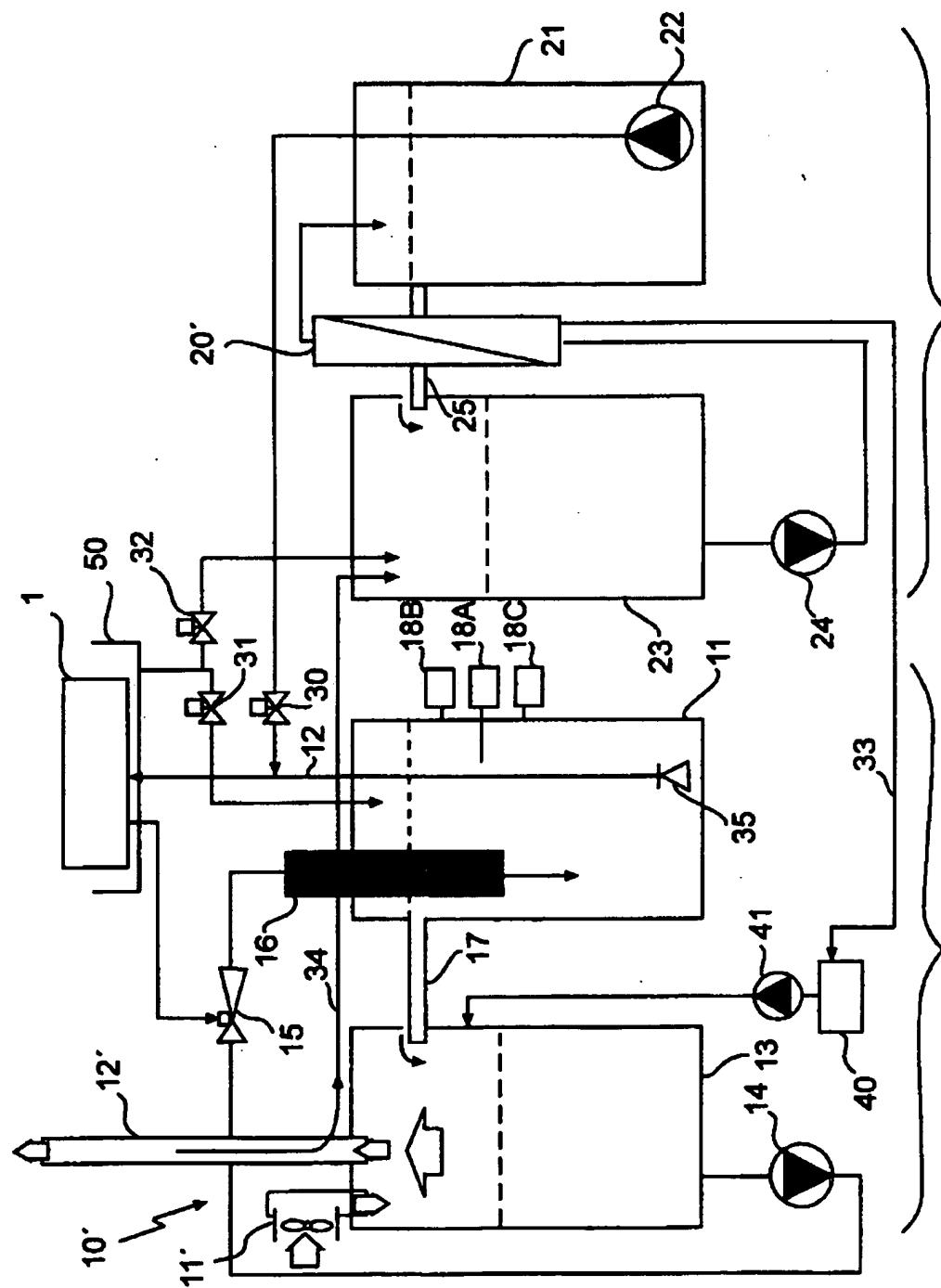


Fig. 2

20

10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/00823

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C23F 1/08, C23G 3/00, C23G 5/00, C25D 21/08, C25F 7/00 // C25D 001/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C23G, C23F, C25D, C25F, B08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

HPIL, EDOC, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-------------------------------------|
| X | US 5173161 A (GERHARD GRAMM), 22 December 1992 (22.12.92), column 1, line 1 - column 5, line 31, figures 1,3 -- | 1-9,11-15, 17-28,30,31, 33,34 |
| X | US 4163705 A (TEUVO T. KORPI), 7 August 1979 (07.08.79), column 3, line 38 - column 4, line 4, figures 2,3 -- | 1-9,11-15, 17-28,30,31, 33,34 |

Further documents are listed in the continuation of Box C.

See patent family annex.

- * Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search

11 July 2001

Date of mailing of the international search report

12-07-2001

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

Ingrid Grundfält/MP
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00823

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|---|
| A | JP 7189000 A (NIKKEI GIKEN KK et al) 1995-07-25 (abstract) World Patents Index (online) London, U.K.: Derwent Publications, Ltd. (retrieved on 2000-10-16). Retrieved from: EPO WPI Database. DW199538, Accession No. 1995-290963 & JP 7189000 A (NIPPON LIGHT METAL CO LTD et al) 1995-11-30 (abstract) (online) (retrieved on 2000-10-16). Retrieved from: EPO PAJ Database -- | 1-34 |
| A | US 3839180 A (KIYOSUMI TAKAYSU), 1 October 1974 (01.10.74), column 1, line 44 - column 2, line 46; column 3, line 5 - line 20, figures 1,2, abstract -- | 3,8,19,33,34 |
| A | DE 3936363 A1 (HANS HÖLLMÜLLER MASCHINENBAU GMBH & CO.), 8 May 1991 (08.05.91), column 3, line 39 - column 6, line 58, abstract, figure -- | 2-5,8,9, 11-13,18-22, 26-28,33,34 |
| A | DE 3939222 C1 (SCHERING AB), 8 November 1990 (08.11.90), column 3, line 13 - column 5, line 51, figures 1-3, abstract -- | 2,4,5,8,9, 13,18,20-22, 25,28 |
| A | DE 2359691 A1 (HEYES JOSEF), 5 June 1975 (05.06.75), page 3, line 14 - page 6, line 5, figure -- | 5,8,13,20, 22,28 |
| A | US 4645575 A (MAURIZIO PODRINI), 24 February 1987 (24.02.87), column 3, line 25 - line 31, figure 1, abstract -- | 15,31 |
| A | US 5180438 A (JURGEN HOCKH ET AL), 19 January 1993 (19.01.93), column 4, line 22 - line 28, abstract, figure -- | 15,31 |

INTERNATIONAL SEARCH REPORTInternational application No.
PCT/SE 01/00823**C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|---|-----------------------|
| A | US 5569330 A (ROBIN SCHILD ET AL), 29 October 1996 (29.10.96), column 1, line 39 - column 2, line 63; column 4, line 16 - line 49; column 6, line 63 - column 7, line 27, figure 1, abstract --- | 1-34 |

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/SE 01/00823

| Patent document cited in search report | Publication date | | Patent family member(s) | | Publication date |
|--|------------------|--|--|--|--|
| US 5173161 A | 22/12/92 | | AT 127865 T DD 289067 A DE 58909438 D EP 0445120 A,B JP 3505348 T WO 9005801 A ZA 8908935 A DE 3903696 A | | 15/09/95 18/04/91 00/00/00 11/09/91 21/11/91 31/05/90 30/10/91 09/08/90 |
| US 4163705 A | 07/08/79 | | BE 841590 A CA 1093012 A CH 620247 A DD 125995 A DE 2619987 A DK 151906 B,C DK 205176 A FI 53841 B,C FI 751337 A FR 2310425 A,B GB 1551340 A HK 97184 A IT 1061259 B JP 1364470 C JP 51149131 A JP 61025799 B NO 148193 B,C NO 761570 A SE 7512925 A SE 8506146 A | | 01/09/76 06/01/81 14/11/80 08/06/77 25/11/76 11/01/88 08/11/76 02/05/78 08/11/76 03/12/76 30/08/79 21/12/84 28/02/83 09/02/87 21/12/76 17/06/86 16/05/83 09/11/76 08/11/76 27/12/85 |
| US 3839180 A | 01/10/74 | | DE 2304406 A JP 48080436 A | | 23/08/73 27/10/73 |
| DE 3936363 A1 | 08/05/91 | | NONE | | |
| DE 3939222 C1 | 08/11/90 | | EP 0434994 A | | 03/07/91 |
| DE 2359691 A1 | 05/06/75 | | NONE | | |

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/SE 01/00823

| Patent document cited in search report | | Publication date | Patent family member(s) | | Publication date | |
|--|---------|------------------|-------------------------|--|---|--|
| US | 4645575 | A | 24/02/87 | AT AT BE BR CA DE DE ES ES FR GB GB IT IT JP NL NO SE SE US | 218285 A 392294 B 902951 A 8503570 A 1278764 A 3525183 A,C 8520383 U 545501 A 8604319 A 2568271 A,B 2162202 A,B 8517612 D 1177925 B 8448617 D 61041795 A 8502113 A 852806 A 462980 B,C 8503576 A 4655894 A | 15/08/90 25/02/91 18/11/85 29/04/86 08/01/91 06/02/86 21/03/91 16/01/86 01/06/86 31/01/86 29/01/86 00/00/00 26/08/87 00/00/00 28/02/86 17/02/86 27/01/86 24/09/90 25/01/86 07/04/87 |
| US | 5180438 | A | 19/01/93 | DE EP | 9013241 U 0476235 A | 22/11/90 25/03/92 |
| US | 5569330 | A | 29/10/96 | CN CN DE DE EP JP JP WO | 1047870 B 1145691 A 4413077 A,C 19537879 A,C 0755571 A 2908277 B 8148458 A 9528736 A | 29/12/99 19/03/97 19/10/95 17/04/97 29/01/97 21/06/99 07/06/96 26/10/95 |

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.